DOE/GO-102001-1165
NREL/BK-710-29267
May 2001

9.5 Measuring and Monitoring Benefits

When an organization makes a commitment giving higher priority to reducing energy costs and protecting the environment, it is important to measure the results of these efforts. Senior managers need this information to justify budgets for capital improvements to produce long-term benefits and to determine the benefits received from these investments. These measurements can provide feedback on whether investments are producing the anticipated benefits. If they are not, monitoring may identify reasons for the shortfalls and help facility managers improve performance with other projects.

Some of these measurements are relatively easy to quantify. For example, energy and water quantities and associated costs are provided monthly to the facility manager, and the cost-benefit of some energy and water reduction measures can be readily determined from those bills. Levels of specific indoor air pollutants can be measured, but the cost-benefit determination is less straightforward. Many issues are not so readily quantified—for example: durability, maintenance, drought-tolerant landscaping, and indoor environmental quality. For projects financed by Energy Savings Performance Contracts, or ESPCs, an annual verification of cost savings is required by statute. Instrumentation and measurements play a role throughout the process, from measuring baseline energy use, to commissioning new systems, to optimizing long-term performance and serving as the basis of performance metrics and contractor payments.

Technical Information

The *FEMP Measurement and Verification (M&V) Guidelines* provide methods for quantifying the savings resulting from the installation of energy conservation measures. The *M&V Guide* helps to verify energy savings at minimum cost, and it is intended to be used with ESPCs and utility program projects discussed in *Section 2.3 – Green Procurement* and *2.4 – Alternative Financing*. The *M&V Guide* was developed by FEMP in parallel with the North American Energy Monitoring and Verification Protocol (NEMVP), ensuring consistency for companies doing business with both the public and the private sectors. More recently, both efforts have resulted in the publishing of the International Performance Measurement and Verification Protocol (IPMVP).

The IPMVP provides a wide range of M&V alternatives, including stipulation based on engineering calculations, metering, and using the results of a short-term test to calibrate computer models. In general, more detailed and labor-intensive efforts yield more information, but the value of the information must be weighed against the cost of the M&V program. Simple, low-cost measurements are often adequate and cost-effective. Energy management system tracking features are an effective way to collect consumption and demand information. Factors affecting the costs of measurement and verification include these:

- The number of energy measures implemented;
- The size and complexity of energy conservation measures;
- The interactions between energy conservation measures; and
- The issue of how risk is allocated between the owner and the contractor in a performance contract.

The appropriate M&V strategy can be determined by assessing the project's complexity and the way risk is allocated between an energy service company and its customer. Risk allocation refers to whether the contractor (a) is responsible only for equipment performance (efficiency), or (b) also bears some risk related to operational factors, such as uncertainty in the load. In an ESPC, the M&V program would evaluate all measures of performance in the contract. For example, a lighting contract might include measurements of both electric power consumption and lighting levels.

Electrical energy: Determining electrical energy consumption is relatively straightforward, and an ordinary electrical meter is adequate for simple daily, weekly, or other longer electrical energy determinations. If consumption versus time is required, either the manual method of taking frequent meter readings or automated data collection is necessary. For the collection of time-based information, split-core current transducers and power transducers can be installed without disconnecting power. Data loggers can be used to collect data, which can then be downloaded as needed.

Photo: Warren Gretz

Careful monitoring of building performance is a key component of effective energy management for any facility.

Electrical demand: Time-based information is essential if electrical demand is to be determined. For this purpose, it is essential to have the appropriate software to determine the "peak" value. The peak can be a time-averaged value over a sliding 15- or 30-minute time frame in which single or multiple spikes are not indicative of the peak as measured by the local utility. Others simply measure the highest demand in a month and base demand charges on that value.

Chilled water and hot water: Btu meters can be installed to determine the energy consumption of HVAC equipment lines: chilled water, hot water, and steam. Simple, reasonably accurate meters can be installed "hot," that is, without needing to turn off the system.

Indoor environmental quality (IEQ): Measuring the benefits of IEQ is difficult but not impossible. IEQ is an aggregate of the environment created by air quality, light, noise, temperature, and humidity conditions. Indoor air quality has received the most attention recently, but the other factors are also important contributors to the sense of well-being of facility occupants. There are methods and instrumentation for measuring pollution levels (including carbon dioxide, carbon monoxide, volatile organics, ozone, particulates, and other air emissions), light levels, noise levels, and indices of comfort, such as mean radiant temperature. Employees can be surveyed to determine their reactions to their indoor environment and their perceptions of its effects on their performance and sense of satisfaction.

It is also important to assess objectively the impacts on employees' performance of measures designed to improve IEQ. Although these measures are more indirect, some of the statistics that may be examined include absenteeism, sick days, and drops in productivity. To make sense of this information, the data must be collected for a significant period of time—both before and after the changes. The Rocky Mountain Institute and Pacific Gas and Electric have conducted several studies linking improvements in IEQ to improvements in productivity. In most Federal facilities, the cost-per-square-foot of the workforce is 20 times greater than the cost-per-square-foot of the building. This huge difference readily demonstrates that investments in IEQ that improve productivity are likely to be rapidly recovered. *Section 8.4 – Productivity in the Workplace* provides more information on this topic.

References

Romm, Joseph J., *Lean and Clean Management: How to Boost Profit and Productivity by Reducing Pollution*, Kodansha America Press, New York, NY, 1994.

Fryer, Lynn, "Tapping the Value of Energy Use Data: New Tools and Techniques," E Source Strategic Memo, E Source, Inc., Boulder, CO, March 1996; www.esource.com.

The FEMP *M&V Guide* and the NEMVP are available through the FEMP Help Desk, (800) DOE-EREC (363-3732), or on the FEMP Web site: www.eren.doe.gov/femp/.

Contacts

For additional information on the Federal *M&V Guide*, call the FEMP Help Desk, (800) DOE-EREC (363-3732), and see www.eren.doe.gov/femp/.

To download the *M&V Guide*, visit the Lawrence Berkeley National Laboratory (LBNL) Web site at www.lbl.gov.